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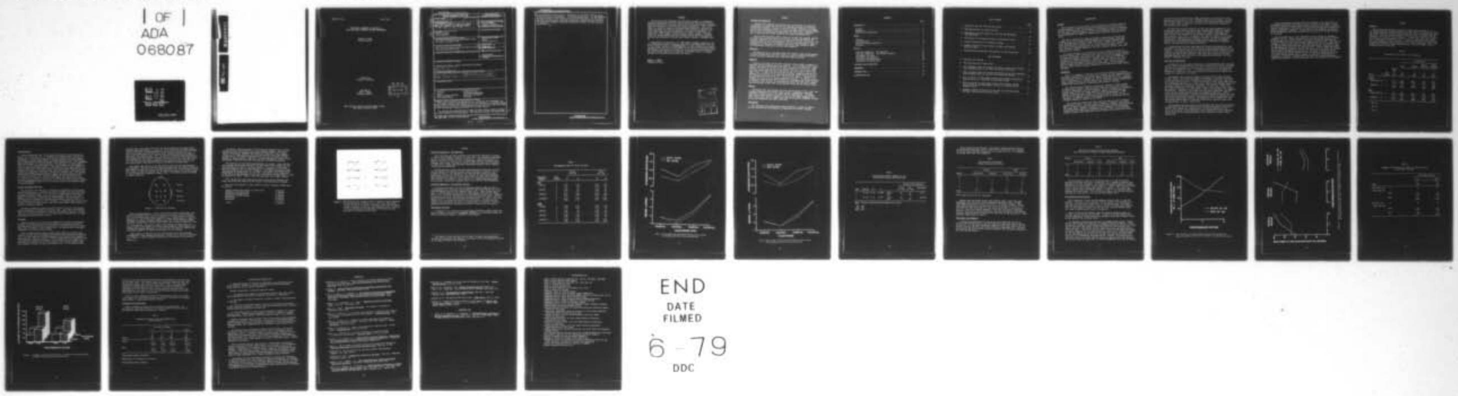

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HEMISPHERIC ASYMMETRY AS RELATED TO PILOT AND RADAR INTERCEPT OFFICER PERFORMANCE

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This report describes the application of a relatively new technology, the visual evoked potential (VEP) method of brain wave analysis, as a possible means of improving the prediction of performance in an area that has proven intractable to more conventional testing procedures--the military aviator.

The subjects were 28 pilots and 30 radar intercept officers (RIOs) assigned to a Navy Readiness Training Squadron. VEP data were obtained from eight scalp

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electrode sites for each aviator. Ratings by the operations officer served as the criterion of performance. It was hypothesized that: (1) VEP amplitude differences would be found between the pilot and RIO groups, and (2) within the pilot and RIO groups, individual performance ratings would be related to VEP hemispheric asymmetry (amplitude differences between the right and left hemispheres).

FOREWORD

This research and development was conducted in support of Independent Exploratory Development Work Unit ZF61-512-001-03.01 (Evaluation of Psychobiological Methods for Enhancing Learning and Performance of Naval Personnel) under the sponsorship of the Director of Navy Laboratories. This is the third in a series of reports on psychobiological methods of improving personnel assessment and enhancing personnel training and performance. The first report showed brain wave measures to be useful in predicting the graduation of Navy remedial reading trainees (Lewis, Rimland, & Callaway, 1976); the second demonstrated relationships between brain wave measures and Navy paper-and-pencil aptitude tests (Lewis, Rimland, & Callaway, Note 1).

Appreciation is expressed to (1) LCDR Kenneth Longeway, formerly of the Naval Postgraduate School, Monterey, California, and LCDR Michael O'Bar and LT Peter Young, formerly of NAVPERSRANDCEN, for their assistance in conducting this study; (2) the staff and members of the VF-121 Navy Readiness Training Squadron, NAS Miramar, San Diego, for their assistance and cooperation; and (3) Professor Gary Poock of the Naval Postgraduate School for making available his information processing test device.

DONALD F. PARKER
Commanding Officer

SUMMARY

Problem and Background

Although paper-and-pencil selection tests are effective in predicting performance in a classroom, they are only marginally useful in predicting on-the-job performance. Because of the Navy's heavy investment in training and the grave consequences that can result from human error, improved methods must be found for predicting the performance of naval aviator candidates and of other personnel being considered for highly demanding duties.

Visual evoked potentials (VEPs), which are derived from computer analysis of brain waves, have been found to be related to mental functioning, and different cognitive activities have been related to various brain sites. The functions served by the left hemisphere (LH) have been described as logical, sequential, and deductive; and those served by the right hemisphere (RH), as simultaneous, integrative, spatial, and judgmental.

Objective

The objective was to determine whether VEP analysis could provide measures of RH and LH functioning that may be used to predict on-the-job performance of naval personnel requiring fast, high-level cognitive skills.

Approach

A group of 28 pilots and 30 radar intercept officers (RIOs) assigned to a Readiness Training Squadron served as subjects. It is considered that pilots require exceptional RH abilities; and RIOs, exceptional LH abilities. Eight channels of brain wave activity were recorded from scalp contact electrodes. Root mean square amplitudes were computed for the wave forms at each of the eight sites. To assess the RH and LH relationships, asymmetry measures were computed by subtracting the LH amplitude value from the RH value for each of the homologous electrode sites (i.e., RH-LH frontal region). Subjects' performance was rated by their squadron operations officer. The VEP data and an information processing task were evaluated by discriminant and graphic analyses to determine their validity in discriminating pilots from RIOs and in assessing relationships between VEPs and performance within the two aviator groups.

Results

Differences were found between the pilot and RIO groups in VEP. Also, the following differences were found between groups in hemispheric asymmetry (amplitude difference between the right and left hemispheres): (1) Higher rated pilots showed greater asymmetry in favor of the right hemisphere than lower rated pilots, and (2) higher rated RIOs showed greater asymmetry in favor of the left hemisphere than lower rated RIOs.

Conclusions

The technology under development seems promising as a means for improving the selection and classification of applicants for aviator training.

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INTRODUCTION

Problem

Paper-and-pencil testing has been used extensively for personnel selection and classification in both the military and civilian sectors for over half a century. While such tests are invaluable in predicting a trainee's performance in a classroom training situation, they are only marginally useful in predicting his performance in "hands-on" training and in real-life on-the-job situations.

The need to develop more effective methods of predicting on-the-job performance is one of the most severe challenges faced by personnel technology. It is estimated that training a single Navy pilot to combat readiness costs about $460,000 (North & Griffin, 1977). Attrition in naval pilot training from 1962 to 1977 has averaged about 30 percent (Griffin & Mosko, 1977). Last year, in-flight accidents resulted in the loss of several aircraft, each costing millions of dollars.

In a recent review of the literature on aviator selection through 1977, North and Griffin (1977) pointed out that only 25 to 40 percent of the variance in aviator performance can be predicted, despite the use of an immense variety of previously available techniques. Although their 145-item bibliography represents an enormous investment in research funds and efforts over a half-century period, the problem remains intractable. Thus, there is clearly a need for improved methods of predicting the performance of naval aviators, as well as that of other personnel required to learn and perform highly demanding tasks.

Background

In 1975, in response to this and other refractory problems in personnel selection, classification, utilization, and training, the Navy Personnel Research and Development Center established the Applied Psychobiology Project. The purpose of the project is to examine such rapidly developing fields as psychophysiology, computer science, and electronics in an attempt to identify technological advances that show promise of alleviating Navy personnel problems.

One area that may be promising for personnel research is visual evoked potential (VEP) analysis. VEPs are minute electrical brain waves, produced by sensory stimulation, which are ordinarily buried in ongoing electroencephalographic (EEG) activity of larger amplitude. Advances in electronics and computer design have made possible the recording and measurement of VEPs. The use of the computer to record and average the VEP so that it may be identified and measured against the background noise of the EEG has provided a dramatic impetus to research in this field.

Two previous VEP studies have been conducted under the Center's Applied Psychobiology Project. The first (Lewis, Rimland, & Callaway, 1976) showed VEPs to be useful in predicting graduation among Navy remedial reading trainees. The second (Lewis, Rimland, & Callaway, Note 1) demonstrated relationships between VEPs and certain paper-and-pencil aptitude tests. In both studies, volunteer subjects were fitted with a Lycra helmet and electrodes were placed

in contact with four paired sites (eight electrodes) on the subject's scalp. Subjects were then asked to watch a flashing light while the computer recorded and calculated VEPs, in real time. Records of brain wave amplitude, habituation, trial-to-trial variability, and latency were recorded in response to the flashing visual stimuli.

The differing functions served by the left and right hemispheres of the brain recently have received a great deal of attention in both the technical and popular press (e.g., Buchsbaum & Fedio, 1969; Dimond & Beaumont, 1974; Galin & Ellis, 1975; Kinsbourne, 1978; Knights & Bakker, 1976; Mintzberg, 1976; Ornstein, 1977, 1978). In general, the dominant (usually left in right-handed people) hemisphere serves functions described as logical, sequential, and deductive. The nondominant hemisphere (usually right in right-handed people) has been described as more influential in simultaneous, judgmental, spatial, and integrative information processing.

It seems likely that most paper-and-pencil tests provide measures of left hemisphere (LH) functions--the kind toward which most classroom instruction is directed. A long-term attempt at this Center to develop paper-and-pencil tests capable of measuring right hemisphere (RH) function for use in selecting naval personnel who must perform practical tasks found that none of the 19 tests developed showed adequate validity for this application (Rimland, 1972; Cory, Neffson, & Rimland, in press).

Objective and Hypotheses

The objective of the present effort was to determine whether VEP technology could be used to provide measures of RH function that will be useful in predicting on-the-job performance of naval personnel in duties requiring integrative, spatial, and judgmental skills. A secondary objective was to determine the feasibility of using new, laboratory-developed psychobiological computer technology in an operational environment.

The subjects were a group of aviators--28 pilots and 30 radar intercept officers (RIOs). Pilots and RIOs might be considered to represent prototypes of the two different kinds of information processing served by the right and left hemispheres respectively. Pilots must be able to cope quickly with problems in three-dimensional space and to make correct split-second judgments based on incomplete information (presumably nondominant, RH functions). While RIOs must perform many pilot-like tasks, many of their duties require them to deal with explicit information in a sequential, logical, and systematic way (dominant, LH functions). Obviously, pilots must also have good LH abilities, and RIOs cannot succeed without good RH spatial and judgmental abilities. Careful educational and psychometric screening of aviation candidates ensures that both pilots and RIOs have above-average intellectual abilities, particularly in the more readily measureable LH skills. Nevertheless, the key elements of pilot and RIO performance might be reasonably categorized as primarily right- and left-hemispheric in nature, respectively.

The foregoing reasoning leads to the hypothesis that the pilot group may be discriminated from the RIO group based on VEP amplitude measures from the LH and RH. This assumes that classification of aviation officers into the pilot and RIO groups, and/or subsequent on-job experience in these respective groups, may lead to a differentiation of the two groups in terms of brain functioning.

A second hypothesis consistent with this reasoning is that the quality of individual pilot and RIO performance may be a function of the degree to which the pilots possess relatively superior RH abilities and RIOs possess relatively superior LH abilities. Differences in RH and LH functioning may be measured in terms of hemispheric asymmetry. In the present study, asymmetry was defined as the RH amplitude value minus LH amplitude values (R-L) at varying locations on the scalp.

Pilots and RIOs may, in fact, represent prototype groups for hemisphere asymmetry research. Doktor and Bloom (1977) used electrophysiological methods in an analogous way in their study of systematic thinking of operations researchers (LH) and holistically-oriented company executives (RH). They reported a change in right-to-left ratios of EEG alpha activity (in the temporal area) for the operations researchers when they performed spatial versus verbal tasks. No differences were found for the executive group. Lawyers (primarily verbal, LH) and ceramicists (primarily spatial, RH) were used in the Galin and Ornstein (1974) study of hemispheric functioning in contrasted occupational groups. Galin and Ornstein used Kinsbourne's (1972) technique of measuring gaze shift of the eyes during thought and in response to questions as indicators of hemispheric activation. Although they found gaze shift differences between lawyers and ceramicists, no EEG differences were found between these two groups.

METHOD

Subjects

The 28 pilots and 30 RIOs who served as subjects were assigned to an F-4 Fighter Readiness Training Squadron at Miramar Naval Air Station, San Diego. The testing took place during a 3-week period on a not-to-interfere-with-training basis. The pilot group included 13 instructors and 15 students; and the RIO group, 16 instructors and 14 students. (It should be noted that "students" are novices only in the regard to the F-4 aircraft. They often have a great deal of experience in other aircraft.) A brief questionnaire was administered to obtain biographical data and information on aviation experience (i.e., total flight hours, number of combat missions, types of aircraft flown.) Table 1 summarizes some of these data.

Table 1

Descriptive Data for Pilot and RIO Groups

Group	N	Left Handed	Age in Years $\bar{X}$ (SD)	Flight Hours: Total $\bar{X}$ (SD)	Flight Hours: Fighter $\bar{X}$ (SD)	Flight Hours: Carrier Landings $\bar{X}$ (SD)	Flight Hours: Combat Missions $\bar{X}$ (SD)
Pilots							
Instructors	13	3	31.2 (1.8)	1741 (663)	1273 (355)	326 (104)	150 (94)
Students	15	0	29.5 (2.8)	1530 (635)	698 (871)	151 (178)	208[a] (65)
RIOs							
Instructors	16	2	29.7 (2.6)	1463 (578)	1131 (345)	313 (120)	112 (118)
Students	14	3	27.8 (4.1)	539 (677)	456 (688)	241[b] (205)	224[c] (81)

[a] N = 4.

[b] N = 6.

[c] N = 3.

Instrumentation

The instrumentation used in this study was similar to that described in Lewis et al, (1976, Note 1). It included a Data General NOVA 2 central processing unit; a dual-drive floppy disk system (Advanced Electronics Design, model 2500); a custom eight-channel, integrated amplifier and filter network; and an alphanumeric oscilloscope monitor (Tektronix model 603). This equipment, which was designed for field portability, was contained in a single cabinet (76 x 61 x 56 cm) and weighed about 82 kg. The remainder of the equipment included a small solid-state keyboard; a flourescent tube and power supply for visual stimulation; a high-speed printer (Centronics, model 306) with acoustic enclosure to attenuate the printer noise (Van San Quietizer, model 5330); and a small EEG preamplifier, multiplex, and optical isolation unit. The computer demultiplexed the electrophysiological signals and further amplified them to a total of 20,000 times. Frequency response of the amplifier was flat to about 150 Hz. Filter roll-off for each channel was about 3 dB per octave and passed signals between 2 and 30 Hz. All of the instrumentation was mounted in the NAVPERSRANDCEN laboratory van, which was parked in the squadron hangar during the testing.

On-site Recording Conditions

One purpose of the study was to determine the feasibility of VEP testing under field conditions. A number of technical problems were encountered with the data acquisition system at the test site, including electrical noise and especially acoustical noise, since the van was parked close to the runway. However, none of these problems proved insurmountable. The van proved to be sufficiently well-insulated to attenuate the external acoustical noise to a level considered satisfactory (about 30 dB(A)). In addition, white noise (about 65 dB(A)) (Bruel and Kjaer Impulse Sound Level Meter, model 2209) proved effective for auditory masking.

The small preamplifier employed optical-isolation circuitry that greatly reduced extraneous environmental electrical noise. Such noise can adversely effect both the data recording from subjects and computer operation. The VEP data are in the one-millionth of a volt range and are very sensitive to small environmental electrical noise levels.

Procedure

Subjects reported to the van, which contained ten carrels for individual testing. After the subjects had been briefed on the research procedures and purposes and had been given an opportunity to read the Privacy Act statement, they were asked to sign a consent form. All subjects were interested, cooperative, and willing to participate.

Before commencing VEP testing, subjects participated in a simple digit response reaction time task designed to determine their information processing rate. The task consisted of three subtasks in which subjects were visually presented with a digit and asked to respond by pressing the corresponding digit on a keyboard as quickly as possible. In the first task, each subject was presented with the digit "2" for 20 successive trials, while response times were averaged to obtain his base line reaction time. In the second, he was

presented with either digit "2" or "3" (in random order) over 20 trials, while response times were averaged to obtain his 1-bit information processing (decision) time. In the third, he was presented with the first four digits--"1," "2," "3," and "4"--in random order over 20 trials, while response times were averaged to obtain his 2-bit decision time. The 1-bit and 2-bit decision times obtained for each subject were then "corrected" by subtracting from each the base line reaction time obtained for that subject. Finally, the slope value of the corrected 1-bit and 2-bit decision times was determined and the inverse of that value was used as a single index of the subject's overall information processing rate.

Each subject was then led to the VEP testing carrel and the VEP procedures were explained. The Lycra electrode helmet was attached to the subject; electrodes were placed in contact with the scalp over homologous sites in the frontal (F3 and F4), central (C3 and C4), parietal (P3 and P4), and occipital (O1 and O2) regions of the left and right hemispheres (Jasper, 1958). The location of the electrodes is shown in Figure 1.

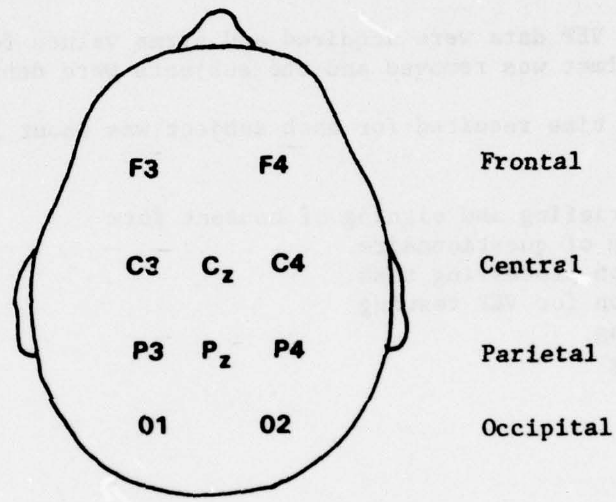

Figure 1. Electrode site montage.

After checking impedance (< 5K Ω) and providing further instructions, each subject was presented with the visual stimulus--a flashing, rear-illuminated 20 x 30 cm diffusing white plastic rectangle--at a viewing distance of approximately 61 cm. The stimulus was flashed for 2 msec, aperiodically at intervals averaging 1.5 seconds. Stimulus luminance was about 48 foot-Lamberts (Gamma Scientific Telephotometric System, model 2009K); and background luminance, about 10^{-2} foot-Lamberts. The visual stimuli were presented to each subject in a single series of 100 flashes; the visual evoked potentials (VEPs) however, were recorded and averaged separately for the first and the second 50 flashes, thus providing an index of the subject's habituation to the stimulus.

Eight channels of VEP data--one for each electrode site--were acquired simultaneously. Each channel was referred to vertex (i.e., the top of the head--C_z in Figure 1), while the subject ground was on the midline in the parietal region (P_z).

All software subroutines used in VEP testing and analyses were on floppy disk and each could be accessed by a single keyboard command. These subroutines included (1) impedance monitoring and calibration, under computer control, of all eight channels, (2) real-time display of the eight channels of EEG activity, (3) subject identification entry, and (4) acquisition and analysis of eight channels of VEP data. Polaroid photographic records of the CRT display of VEP data were made following each 100-flash presentation.

The time base for each VEP was approximately 0.5 seconds. After the VEPs were acquired, an amplitude microvolt root mean square value (μVrms) was computed separately for each of the eight channels. A total of 16 amplitudes were thus computed; that is, eight channels x two waveforms (one each for the first 50 and the second series of 50 flashes). This amplitude measure (μVrms) approximated the average power for each VEP. More detail on the computation of VEP μVrms and the rationale for its use is provided in Callaway (1975, p. 150) and Lewis et al. (1976). Figure 2 shows VEP waveforms from a sample subject.

After the VEP data were acquired and μVrms values for each waveform computed, the helmet was removed and the subjects were debriefed and released.

The total time required for each subject was about 55 minutes, broken down as follows:

Initial briefing and signing of consent form	10 minutes
Completion of questionnaire	5 minutes
Information processing task	10 minutes
Preparation for VEP testing	10 minutes
VEP testing	10 minutes
Debriefing	10 minutes
Total	55 minutes

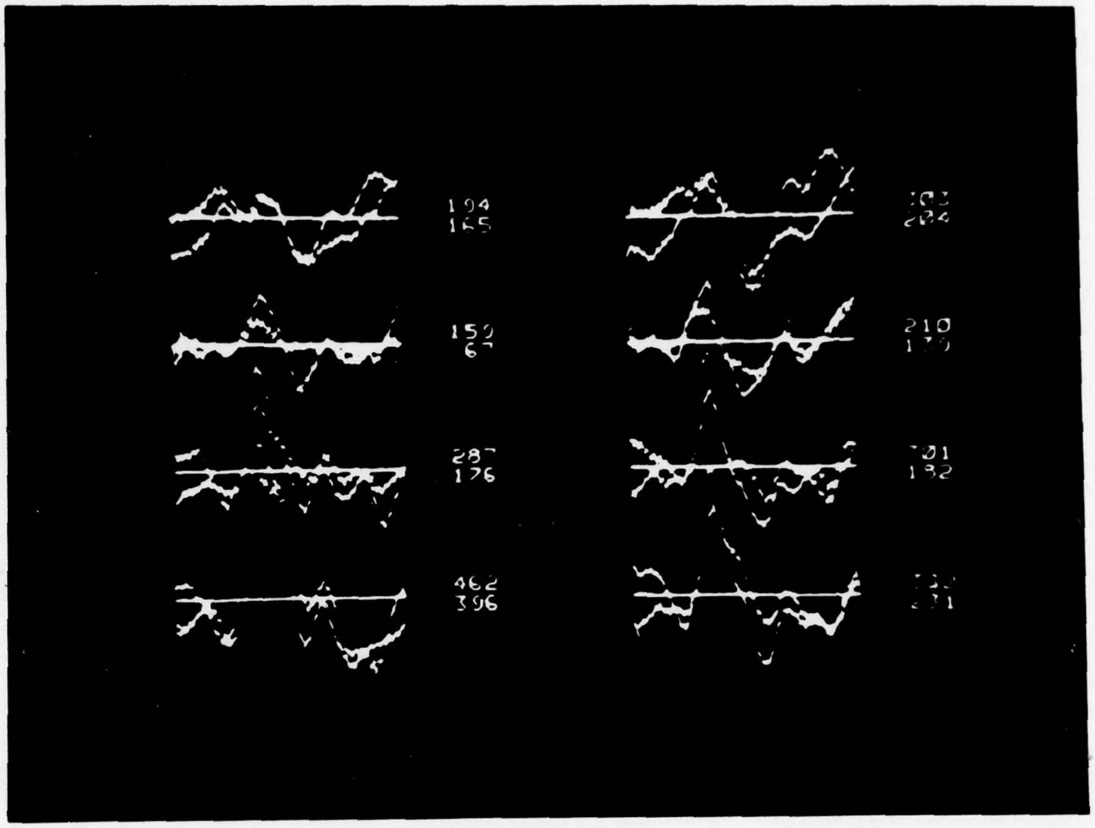

Figure 2. VEP waveforms from a sample subject. Numerical values presented are the rms values in μV/100 for the first (top) and second (bottom) series of 50 flashes. Waveforms in the left and right columns correspond to left and right hemisphere sites. From top to bottom, the waveforms correspond to the frontal, central, parietal and occipital cortical areas.

RESULTS

Pilot-RIO Comparison: VEP Amplitude

Since the pilots and RIOs performed rather different functions, we wished to find if they differed, as groups, in their VEPs. Any difference found might be due to either selection factors or experience. Initial self-selection or explicit selection, as well as self- or operational selection during or after training, could result in groups of pilots or RIOs that were quite dissimilar. It might also be argued that experience differences during or after training could cause VEP differences.

The VEP amplitude (μVrms) mean and standard deviation values for the pilot and RIO samples are presented in Table 2 and illustrated in Figures 3 and 4. As shown in Table 2, left hemisphere (LH) amplitude mean values for pilots exceed those for RIOs for all but one site (frontal 2), and right hemisphere (RH) amplitude mean values for pilots exceed those for RIOs in all but three sites (central 2, occipital 1, and occipital 2). Standard deviation values for the pilots consistently exceeded those for the RIOs for both hemispheres.

Pilot-RIO Comparison: Discriminant Analysis

To estimate the extent to which VEP amplitude measures might be used to differentiate pilots from RIOs, all 16 amplitude values were entered in a stepwise discriminant analysis (DA) (BMD07M, Dixon, 1973). Table 3 shows that, at Step 1 of this analysis, pilots were best discriminated from RIOs by variate C3 (1) (i.e., the first 50-flash VEP at the LH central cortical site). Although 60 percent of the pilots and RIOs were correctly classified at Step 1, the chi-square statistic did not reach statistical significance.[1] At Step 2, the F3 (2) variate (i.e., the second 50-flash VEP at the LH frontal cortical site) was selected, which increased the correct classification to 71 percent. The chi-square was statistically significant with Yates' correction for continuity.

Performance Criterion

In addition to our interest in possible group differences between pilots and RIOs, we wished to determine if individual differences in performance within the pilot and RIO groups might be reflected in VEP measures.

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[1]The number of cases available was too small to permit cross validation. Statistical significance here refers to the success of the discriminating function in the sample on which it was developed.

Table 2

VEP Amplitude Data for Pilots and RIOs

Hemispheric Region	Flash Series	Pilots (N = 28) $\bar{X}$	Pilots (N = 28) SD	RIOs (N = 30) $\bar{X}$	RIOs (N = 30) SD
Left					
Frontal	1	1.91	1.14	1.82	.56
	2	1.75	.98	1.78	.65
Central	1	1.56	.64	1.19	.45
	2	1.37	.61	1.16	.32
Parietal	1	2.72	1.26	2.40	.99
	2	2.61	1.45	2.24	.95
Occipital	1	4.78	1.65	4.64	1.54
	2	4.66	1.76	4.57	1.64
Right					
Frontal	1	2.19	1.27	2.02	.62
	2	2.03	1.06	2.02	.84
Central	1	1.61	.64	1.56	.47
	2	1.46	.54	1.49	.41
Parietal	1	2.88	1.34	2.63	.78
	2	2.80	1.31	2.50	.78
Occipital	1	4.58	1.58	4.60	1.37
	2	4.58	1.65	4.61	1.52

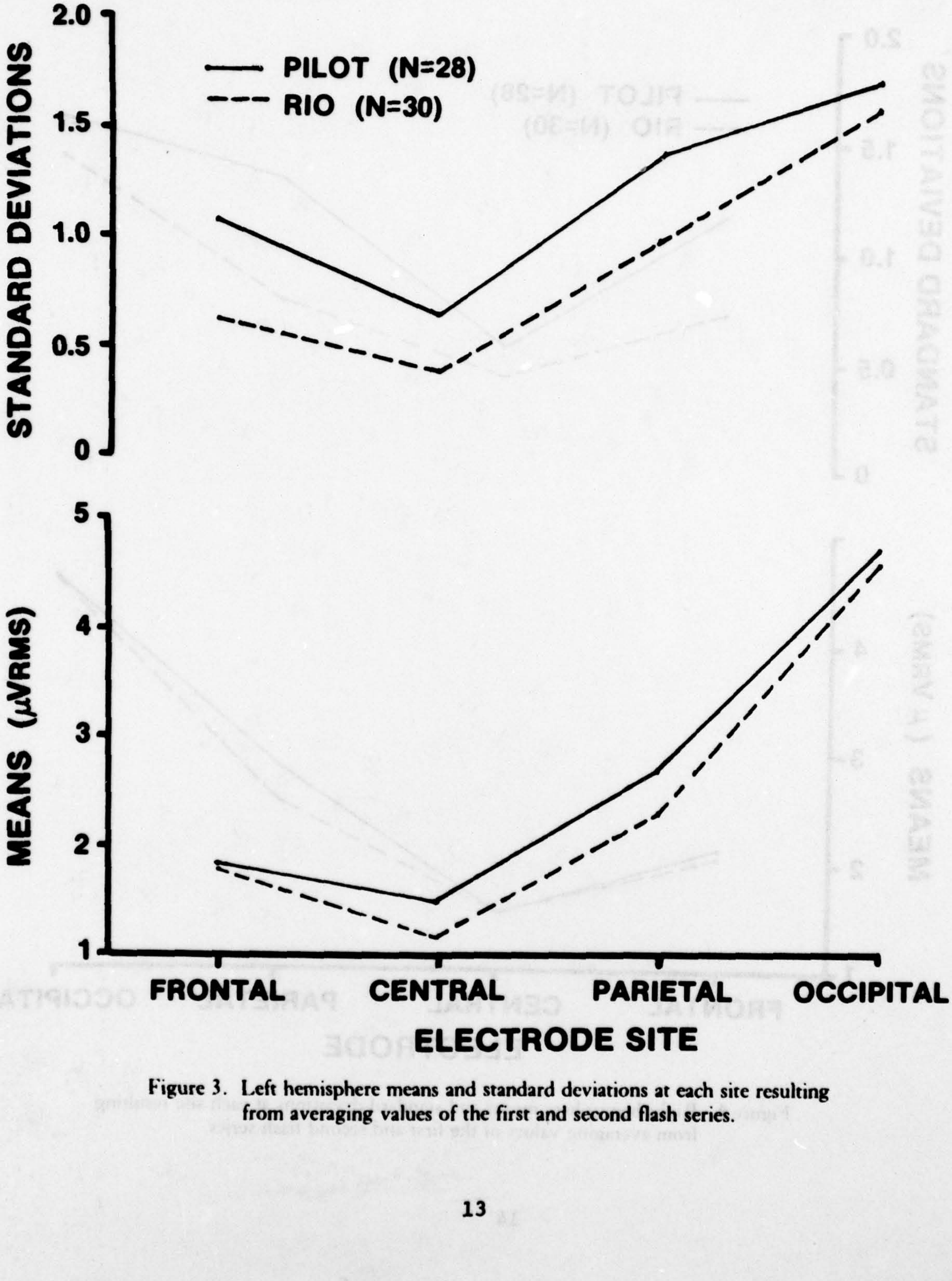

Figure 3. Left hemisphere means and standard deviations at each site resulting from averaging values of the first and second flash series.

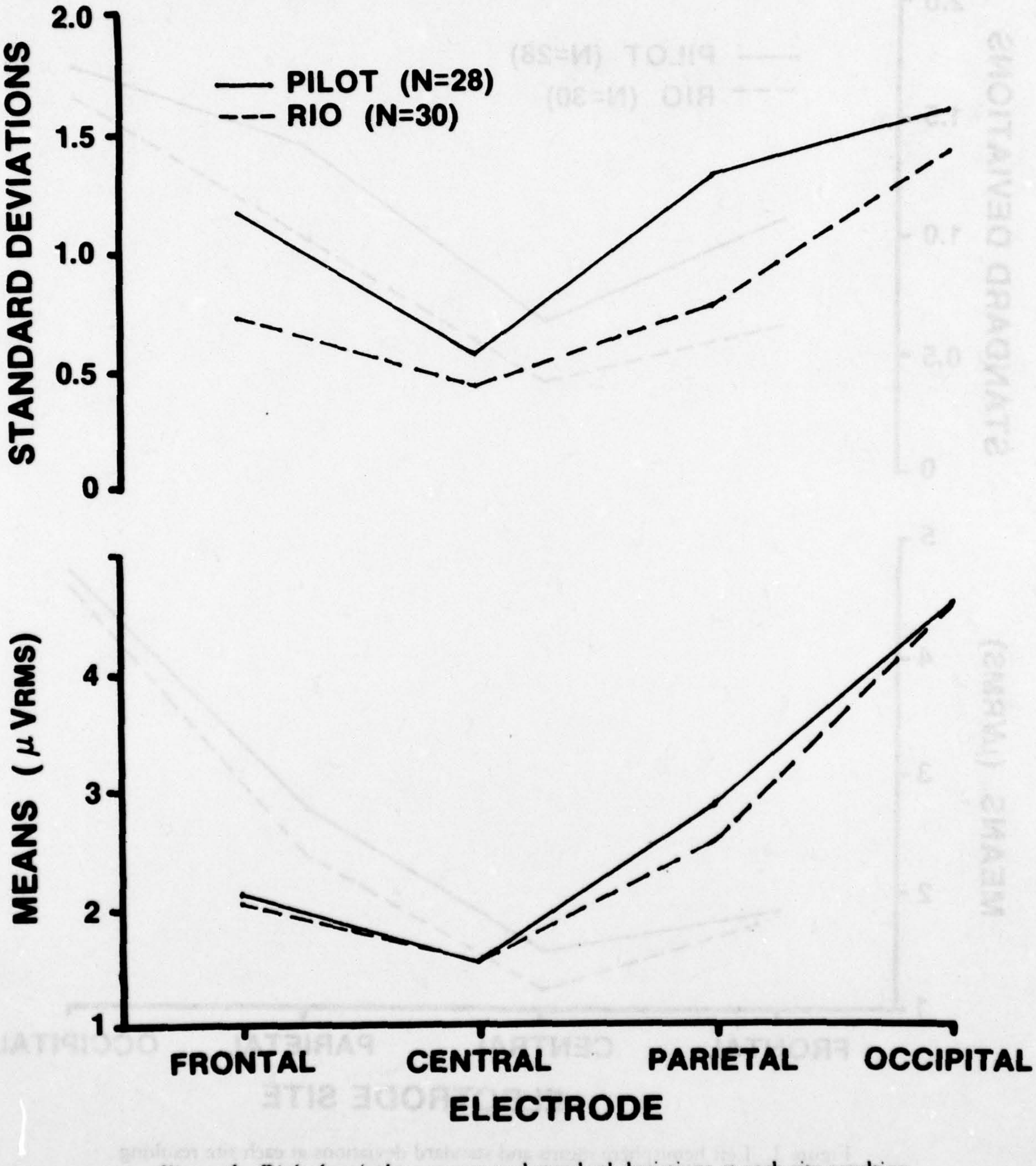

Figure 4. Right hemisphere means and standard deviations at each site resulting from averaging values of the first and second flash series.

Table 3

Discriminant Analysis Summary for the Pilot and RIO Groups (VEP Amplitudes)

					Classification Matrices		
Step	Variate	df	F		Pilot (N = 28)	RIO (N = 30)	Chi-square
1	C3 (1)	1, 56	6.53**	Pilot	12	16	1.70
				RIO	7	23	
2	F3 (2)	1, 55	5.28*	Pilot	20	8	8.35***
				RIO	9	21	

Note. Correct classification decreased after Step 2.

*$p < .05$.
**$p < .02$.
***$p < .01$.

Table 4 shows the distribution of performance ratings assigned subjects by the squadron operations officer. The pilots and RIOs were to be compared with other pilots and RIOs respectively on a scale of 1 to 10. In actuality, no ratings lower than 6 were assigned.

Table 4

Distribution of Performance Ratings by Operations Officer

	Pilots		RIOs	
Rating	Instructors	Students	Instructors	Students
10	2	-	4	-
9	8	1	8	3
8	3	8	4	8
7	-	4	-	3
6	-	1	-	-
Total	13	14[a]	16	14

[a]One student was too new for evaluation.

Because some left-handed persons have dominant right, rather than left, hemispheres, and others show little hemispheric dominance, data for eight left-handed aviators were removed from most of the further analyses. These eight aviators included three instructor pilots (1 rated 8; 1, 9; and 1, 10), two instructor RIOs (both rated 9), and three student RIOs (2 rated 8 and 1 rated 7). Since the students appeared to have been consistently downgraded one point for lack of relevant experience, one point was added to each student rating to place the student ratings on the same scale as the instructors. These adjusted ratings appear in Table 5.

Performance and Asymmetry

It had been hypothesized that high-rated pilots would show greater RH activity than low-rated pilots, and that high-rated RIOs would exhibit greater LH activity. To test these hypotheses, asymmetry values were computed for the frontal, central, parietal, and occipital RH and LH amplitudes (i.e., RH minus LH at each of the four regions) and plotted against the performance ratings for the pilot and RIO groups.

Table 5

Adjusted Distribution of Performance Ratings
(One Point Added to Student Ratings; Left-Handers Removed)

Rating	Pilots			RIOs		
	Instructors	Students	Total	Instructors	Students	Total
10	1	1	2	4	3	7
9	7	8	15	6	6	12
8	2	5	7	4	2	6
Total	10	14	24	14	11	25

The percentage of aviators in the groups rated 8, 9, and 10 whose RH amplitude was greater than their LH amplitude (i.e., asymmetry favoring right hemisphere) was then determined. The clearest hypothesized asymmetry relationship was seen in the parietal region (Figure 5). Similar plots for the frontal, central, and occipital regions are presented in Figure 6. The frontal and central regions show relationships similar to those for the parietal region, although less well-defined. For the occipital region, the pilot-RIO relationship held for those rated 10, but not for those rated 8 or 9.

Front-Back VEP Relationships

Most discussions of brain and VEP asymmetry concern right vs. left differences. Relatively little attention has been devoted to the possible significance of front-to-back differences. In the present study, recordings were made from four paired sites: frontal, central, parietal, and occipital. Thus, it was decided to analyze data for the front and back combined sites, as a means of exploring this aspect of asymmetry.

Table 6 shows the VEP asymmetry mean and standard deviation values for the high- and low-rated pilots and RIOs. In order to provide general front-to-back comparisons, frontal and central asymmetry values were combined (front) as were parietal and occipital (back).

No consistent relationships were seen for asymmetry mean values. However, several relationships were observed for asymmetry standard deviations. These are depicted in Figure 7, which shows the standard deviations plotted for groups (pilots and RIOs), performance ratings (high and low), and electrode sites (front and back). The SDs for both the high-rated pilots and high-rated RIOs were about equal at the front and back sites. Also, for both high-rated groups, the SDs were greater for the back than for the front sites. The SDs obtained for the low-rated groups at the front and back sites were much greater than those for the corresponding high-rated groups. Further, the SDs obtained for low-rated pilots at the front and back sites were greater than those obtained for low-rated RIOs at these sites. As with the high-rated pilot and RIO groups,

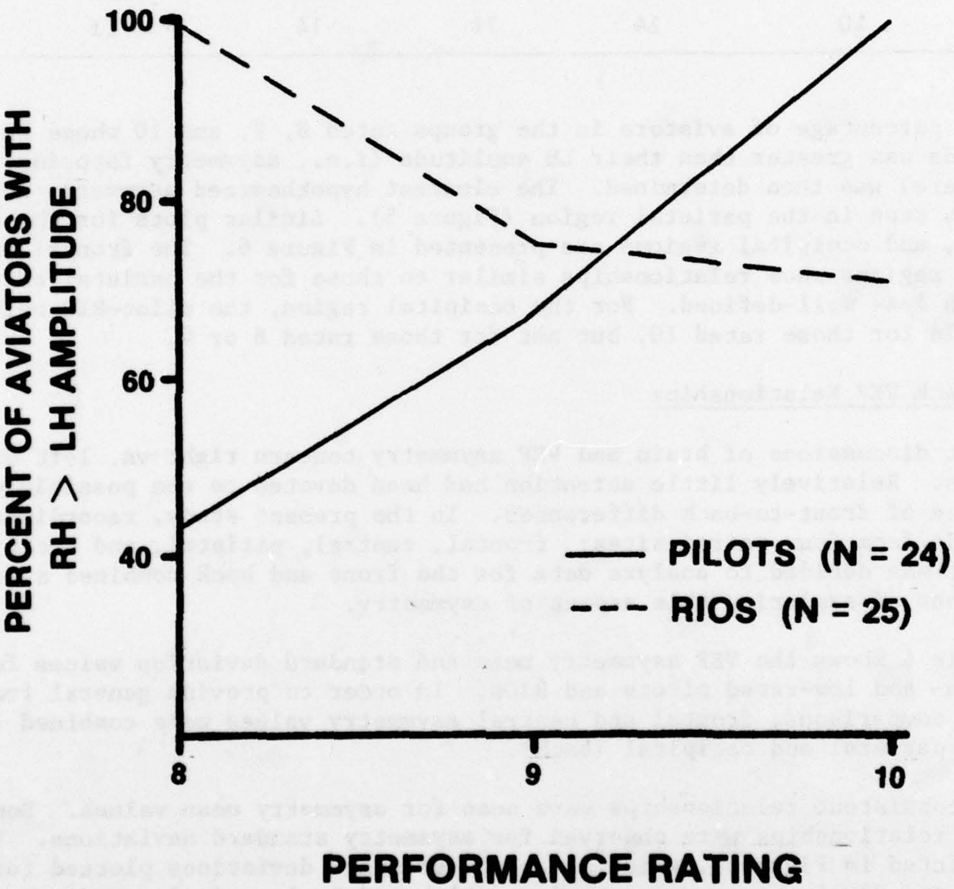

Figure 5. Plot of percent of right-handed aviators with parietal RH amplitude greater than LH, as a function of performance rating.

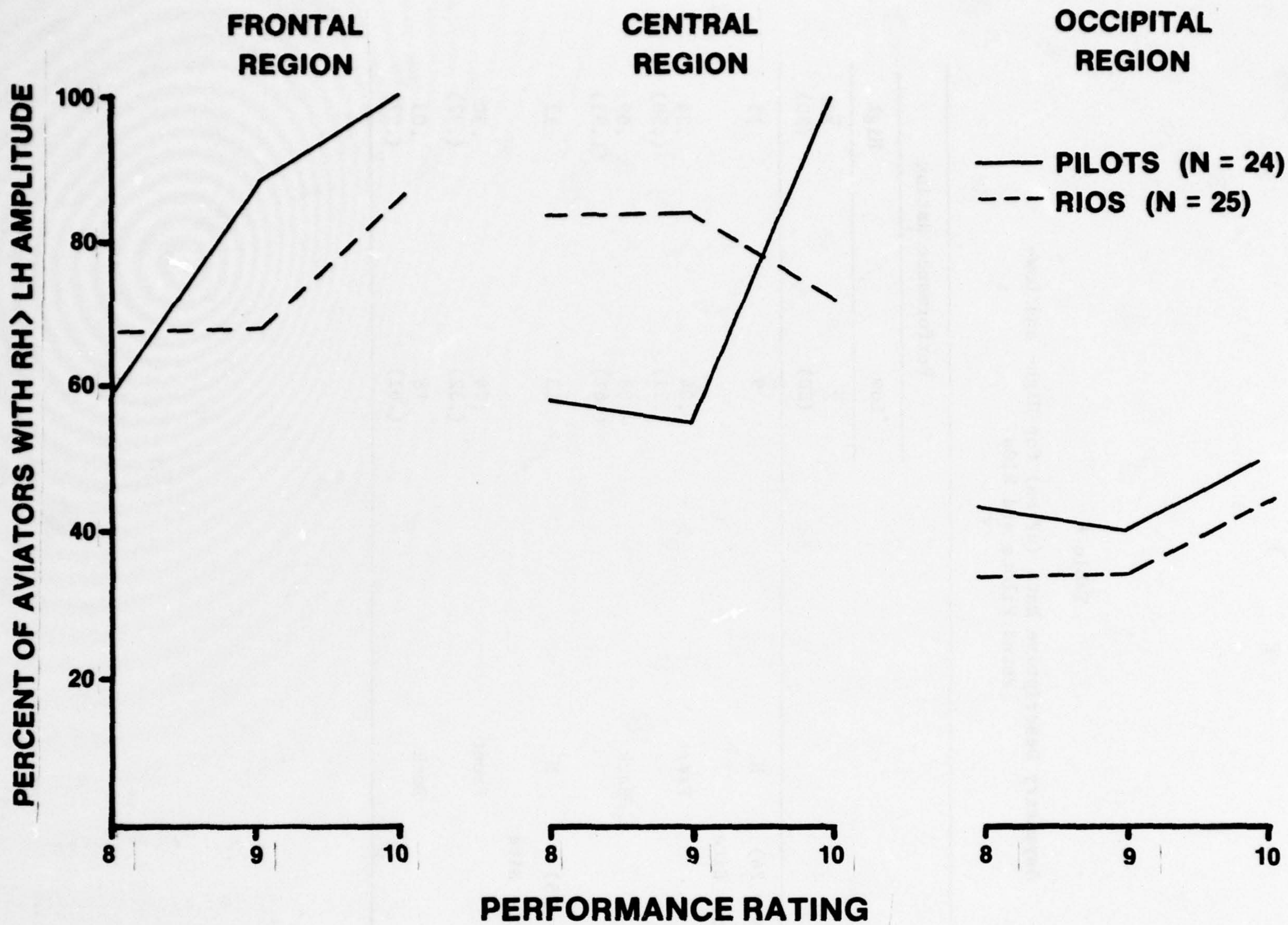

Figure 6. Plots of percent of right-handed aviators with frontal, central, and occipital RH amplitude greater than LH as a function of performance rating.

Table 6

Asymmetry Descriptive Data (μVrms) for High- and Low-Rated Pilots and RIOs

		Performance Rating	
		Low	High
Group		$\overline{X}$ (SD)	$\overline{X}$ (SD)
Pilots (N = 24)	N	9	15
Electrode Site			
	Front	.04 (.31)	.24 (.58)
	Back	-.08 (.61)	.09 (1.32)
RIOs (N = 25)	N	13	12
Electrode Site			
	Front	.24 (.32)	.30 (.37)
	Back	18 (.61)	.03 (.97)

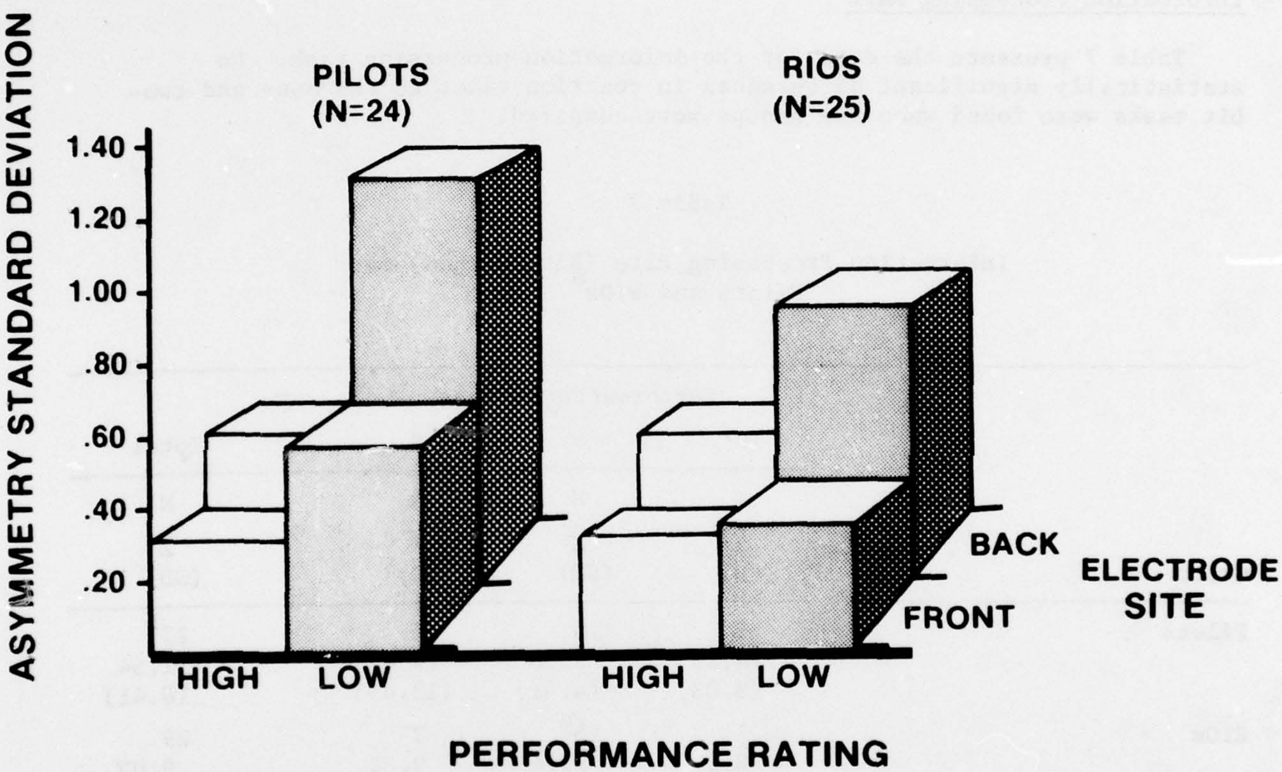

Figure 7. Asymmetry standard deviations for the high- and low-rated pilots and RIOs, front and back electrode sites.

the SDs for the low-rated pilot and RIO groups were greater for the back than for the front sites. The parietal region is a primary association area; and the occipital region, the primary visual reception area. The front site includes both an association area and a motor area. The task required only observing a blinking light; no motor activity was needed. The greater heterogeneity of the low-rated pilot and RIO groups as compared to the high-rated groups may be a result of the fact that there may be many ways to perform poorly, but few ways to perform well.

While the above findings may seem to be adventitious, they are nevertheless thought to be worth reporting because they were replicated in a recently tested sample of antisubmarine warfare trainees.

Information Processing Rate

Table 7 presents the data for the information processing task. No statistically significant differences in reaction times to the one- and two-bit tasks were found when the groups were compared.

Table 7

Information Processing Rate (Bits/Second) for Pilots and RIOs[a]

	Performance Ratings			
	10	9	8	Total
Group	N $\overline{X}$ (SD)	N $\overline{X}$ (SD)	N $\overline{X}$ (SD)	N $\overline{X}$ (SD)
Pilots	3 14.25 (8.03)	16 9.56 (4.41)	8 14.47 (13.45)	27[b] 11.54 (8.41)
RIOs	7 8.50 (2.70)	15[c] 9.14 (5.27)	7 9.32 (2.74)	29 9.03 (4.14)

[a]Left-handed subjects included.

[b]Rating was not available for one pilot.

[c]One extreme outlier removed.

DISCUSSION AND CONCLUSIONS

As indicated earlier, this study was undertaken as an exploratory field trial, primarily intended to evaluate technology and research strategies rather than as a test of specific hypotheses.

Several limitations of this study should be noted:

1. The samples were composed of experienced aviators; thus, the results were confounded by restriction of range and the effects of experience.

2. The number of subjects tested was too small to permit cross-validation of findings.

3. Pilot and RIO performances were rated by only one person and were of limited range and reliability. Ideally, objective performance and/or simulator-derived proficiency measures should be used.

4. The stimulus used to evoke the brain potentials consisted of a simple flashing light. Newly developed equipment will make it possible to present more appropriate, task-relevant visual and auditory stimuli to the subjects.

Despite the limited goals and limitations of this study, several promising findings were observed. These include psychobiological differences between pilots and RIOs that provide preliminary confirmation of the hypothesized differences between right hemisphere and left hemisphere functioning in pilots and RIOs.

In discussing the EP differences between pilots and RIOs, we noted the possibility that the EP findings could be the result of endogenous and/or experiential factors. Subsequent analyses relating flight experience to the VEP measures show markedly greater VEP asymmetry dispersion among aviators (pilots and RIOs) with a moderate amount of flight experience (900-1500 hours) than among those with a larger amount of experience (1600-2400 hours). Further analyses are continuing.

Since collecting the data reported above, stimulus data recording and analysis techniques used have been refined. It is planned to test additional samples to determine if the findings reported here can be replicated and extended. These plans will involve testing a sample of antisubmarine warfare trainees, a second and larger sample of pilots and RIOs, and perhaps certain other groups for which RH brain functioning appears to be an important component of high performance (e.g., Combat Information Center officers).

The present study included samples modified by attrition and experience. Of special interest will be the testing of samples of applicants, to determine if those who attrite early could have been identified by VEP testing. If findings continue to be positive, and suitable levels of accuracy can be achieved, a recommendation will be made to operationally adopt psychobiological techniques in personnel selection and classification.

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